PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Bonded Abrasive Articles

(A communication from THE CARBORUNDUM COMPANY, a Corporation of the State of Delaware, United States of America, of Niagara Falls, in the County of Niagara and State of New York, United States of America).

I, WILLIAM JOHN TENNANT, a British Subject, of 111/112, Hatton Garden, London, E.C.1, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the production of bonded abrasive articles and has for one object the construction of an abrasive article wherein the abrasive granules are held firmly in a setting of binder whereby they continue to cut until worn away. This is in contradistinction to the action of ordinary abrasive articles wherein it is intended that when an abrasive granule is worn to dullness the increased friction causes the granule to fracture, exposing a fresh cutting edge, or to break out of the bond structure entirely, making way for bringing into action an unworn granule. In further contrast to ordinary abrasive articles, those with which the present invention is concerned are extremely dense with substantially all the space between the abrasive granules filled with binder and require periodical sharpening to bring fresh cutting edges into play, whereas ordinary abrasive articles are somewhat porous to facilitate the action described above.

An extremely dense structure is made necessary by the character of the work to be done, or by the nature of the abrasive material used. In cutting certain extremely hard materials a relatively porous bond structure would be so weak as to let loose the abrasive granules at the first attempt to cut the material thereby making the cutting operation inefficient with respect to the work. In the use of certain rather expensive abrasives, such as diamonds and boron carbide, this premature breaking out of the granules before they have been completely used up would render the process inefficient with respect to the abrasive regardless of the work.

It has been suggested to bond abrasive granules into dense cutting tools by means of metals, for example by mixing them with molten metal such as zinc or by mixing the abrasive, specifically diamonds, with finely divided electrolytic iron particles and moulding the mixture under great pressure to form a dense homogeneous article.

Such articles have a number of disadvantages however. As stated above they must be dressed or sharpened periodically as the granules wear to remove bond from around the granules to enable them to penetate the work, and provide space for accumulation of material cut from the work. This is difficult to do without unduly loosening the granules from their foundation, especially in the case of finely divided abrasive material because of the small spaces between adjacent grains and the relative softness of the bonds used. For this reason it is practically impossible to use satisfactorily in this way extremely fine abrasive material, such as the diamond dust produced in crushing and otherwise preparing larger granules for use. Furthermore, there are certain disadvantages in the use of dense metal bonds with respect to the action of the wheel as a whole. More accurately, it might be said that there are certain valuable characteristics of an abrasive article bonded with other materials, such as resins or rubber, which are not present in a metal article. These advantages are difficult to define but no less present and may be said to give a grinding wheel better grinding characteristics.

According to the present invention there is provided a dense non-porous bonded abrasive article composed of preformed aggregates of diamond or hard carbide abrasive and a metallic bonding material, which aggregates are bonded together into a dense structure by another bonding material which is relatively soft and yielding and which substantially completely fills all spaces between the aggregates. In one form of the article the preformed aggregates consist of boron carbide crystals embedded in the metallic bonding material.

The bonding material for forming the abrasive aggregates is hard and brittle relatively to the binder for massing the said aggregate together and may comprise an alloying ingredient such as to accentuate these characteristics.

The abrasive aggregates may conveniently be formed by incorporating the abrasive particles in a metallic bonding material while it is in a softened or liquid condition and in the presence of a non-oxidising atmosphere. It is also of advantage to subject the mixture of abrasive particles and softened or liquid metal to a jarring action.

The binder used for bonding the aggregates may be any one which can be put in a liquid or plastic form, as in solution or in the molten state, whereby it will penetrate and fill all spaces in a mass of aggregates. It is preferably a heat-hardenable resinous binder and may, for example, be a solution of the resinous binder, or a mixture of the liquid resinous binder and finely divided solid resinous binder; alternatively, a molten thermoplastic binder such as certain resins and metals may be used. Of course, the binder selected should be one which can be used at a temperature which will not injure the binder in the aggregates.

By means of the invention, use may be made of small abrasive granules to provide an abrasive article with the cutting power and clearance spaces characteristic of abrasive structures utilising large abrasive granules. One important application of the invention is to the employment of abrasive dust which could otherwise not be utilised in a bonded condition in the production of abrasive articles whose properties approach those of articles formed with larger abrasive granules.

The invention will further be described with reference to the following specific examples. Furthermore, although the invention specifically provides a means of using fines from valuable abrasive materials it is evident that the principles of the invention apply to use of other, larger, or less expensive abrasive materials.

EXAMPLE I.

Diamond particles can be incorporated in metals such as copper, nickel or cobalt. They can also be incorporated in metal alloys, such as those used to hold tungsten carbide particles in forming very hard cutting tools. In the process of incorporating diamond particles in metal the diamonds are mixed with metal which is in finely divided form. The amount of bond material used is that needed substantially to fill the volume between the abrasive particles. Simple calculations based upon the specific gravity, apparent density, grit size, etc. of the materials to be used permit the calculation of this amount with reasonable accuracy. The mixture is pressed and subjected to temperatures ranging from approximately 700° C. to 1500° C. depending on the metal used. Diamonds are subject to oxidation at temperatures above 700° C. It is desirable therefore that the heating should be performed in a non-oxidising atmosphere such as may be produced by deposition of finely divided carbon on the mix or by the use of an atmosphere of hydrogen. A hydrogen atmosphere facilitates the "wetting" of the diamond particles by the metal. It is desirable also that the heating should be rapid to minimise the action of any residual oxygen in the mix on the diamonds. The mix can also be subjected to jarring while the metal is in a liquid or softened condition in order to bring the metal into closer contact with the abrasive particles, so that the attractive forces between the metal and the abrasive particles may be more fully utilised and so that a dense mass of metal and included abrasive may be obtained. After the mixture has cooled the mass is broken up by any convenient method common to the art of crushing into aggregates each of which has a plurality of abrasive particles.

Another hard abrasive that can be thus incorporated with metal is boron carbide. Boron carbide can be alloyed, or incorporated into intimate mixture, with a number of metals, and metal-bonded aggregates can be prepared by either of the following processes.

EXAMPLE II.

Powdered metal or metals, such as copper, silver, nickel, cobalt, iron, and boron carbide particles are mixed. The mixture is pressed and then heated somewhat above the melting-point of the metal to bring the metal into intimate contact with the boron carbide particles. In some cases such intimate contact can be obtained by "sintering" the mixture at temperatures below the temperature of complete melting of the metal. After the mass thus formed has cooled it is subdivided into aggregates.

EXAMPLE III.

A mixture of boron carbide and a metal is heated until the entire mass becomes fluid. On cooling the mass the boron carbide crystallises to give fairly well developed crystals embedded in a metal matrix. The temperature required to produce fluidity of the entire mass is usually about 2000° C. or higher, depending on the metal used and on the proportions of metal and boron carbide.

Example of metals which can be used singly or in combination in this manner with boron carbide are copper, nickel, cobalt or iron. The cooled mass is broken up into aggregates containing boron carbide crystals and interconnecting metal.

In the production of metal bonded aggregates, alloying agents may be incorporated into the metal to produce a satisfactory degree of brittleness for crushing purposes and to give the proper grinding action. These addition agents are well known in the metallurgical art and need not be described in detail. As specific examples, copper can be embrittled by the addition of tungsten, aluminium or tin, the amount added being dependent upon the properties desired in the bonded aggregate. This also constitutes a mechanism for controlling the slow but necessary breakdown of the metal bonded aggregate during use; this in turn makes possible considerable control of the cutting properties of the abrasive article because the brittleness or toughness of the bond and abrasive may be adjusted to suit the character of the cutting action desired. Copper may also be embrittled by dissolving therein boron carbide as disclosed in Example III.

After a dense mass containing abrasive particles distributed throughout has been prepared by one of the methods described above, it is broken up into much smaller aggregates in each of which a number of abrasive particles are held in a comparatively non-porous lump or aggregate. These lumps or aggregates are then admixed with a bonding material such as a heat-hardenable resin; e.g., a phenolic condensation product resin in the A or B stage. In view of the comparatively non-porous character of the aggregates they can be moulded with such a resin bond (and inert filler if desired) into a compact body having few pore spaces. The tendency is for the resinous bond to flow into and fill any pores of the abrasive aggregates. The moulded body is cured at high pressures and at temperatures which produce a curing of the bond, and the body may be subjected to a baking process to further cure the bond.

Instead of a bonding material composed of a heat-hardenable resin, a thermoplastic resin can be used. An example of such a resin is a polymerised resin that can be made from a vinyl acetate base. The vinyl acetate is polymerised by means of light or heat until the viscosity of a molar solution of the resin in benzol is about 15 centipoises. About seventy percent. of the acetate groups are replaced by acetaldehyde. The resultant resin is thermoplastic and is well adapted for moulding in combination with fillers to form strong structures of low porosity. It is also possible to use mixtures of thermoplastic and heat hardenable types of resin to bring about desired elasticity, toughness and resilience of the bond.

Articles made according to this invention may be somewhat smooth surfaced when first made. They may be made ready for use by subjecting the working surfaces to a gentle discing action by oscillating the article slowly over a surface plate charged with fine, granular loose abrasive which cuts away the bond between the aggregates due to its relative softness and also small portions of bond from the abrasive clusters, thus leaving protruding cutting edges. This discing process or its equivalent, may be resorted to periodically during the use of the article to remove any detritus lodged in its working surface or to bring new cutting edges into use.

It is an important advantage of the invention that a structure having relatively fine abrasive granules may be provided with relatively large clearance spaces between aggregates. Relatively large non-abrasive spaces on the working face of the abrasive article are filled with the binder for the aggregates, which spaces may be made concave or hollow by removal of the binder therefrom by a proper dressing action to provide clearance spaces for the abrasive granules and space for the accumulation of material removed from the work. Since the binder for the aggregates is made relatively softer than the binder for the grains, the dressing action will tend to remove more material from between the aggregates than in the aggregates, thus providing the proper setting for the aggregates.

Abrasive wheels made by bonding abrasive aggregates of the type described above and in the manner described have many advantages. The abrasive granules are surrounded for the most part by a bonding material forming the aggregates that adheres more firmly to the abrasive granules than most resinous bonds. Again, the abrasive aggregates have a comparatively large size and can be made with roughened surfaces so that a resinous bond used in uniting the aggregates can hold the aggregates strongly. Moreover, the use of different bonding materials in combination with closely compacted abrasive aggregates makes it possible to obtain an exceptionally wide range of cutting characteristics.

The present invention makes it possible to use more efficiently abrasive dusts such as diamond fines, since the aggregates give some of the effects of larger abrasive

particles such as are commonly selected for use in the manufacture of bonded diamond articles. There is always an excess of fine grit material produced in crushing diamonds or hard carbide abrasive materials, which are rare and costly, to obtain the larger sizes used for making abrasive wheels or other abrasive articles. Insufficient market exists to absorb the quantities of fines produced and the material is therefore relatively inexpensive. This invention makes it possible to utilise the fines to do a large portion of the work of coarser, more expensive grits.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, as communicated to me by my foreign correspondents, I declare that what I claim is:—

1. A dense non-porous bonded abrasive article composed of preformed aggregates of diamond or hard carbide abrasive and a metallic bonding material, which aggregates are bonded together into a dense structure by another bonding material which is relatively soft and yielding and which substantially completely fills all spaces between the aggregates.

2. A dense non-porous abrasive article as claimed in claim 1, wherein the preformed aggregates consist of boron carbide crystals embedded in the metallic bonding material.

3. A dense non-porous abrasive article as claimed in claim 1 or claim 2, wherein the metallic bonding material comprises an alloying ingredient such as to render the bonding material hard and brittle.

4. A dense non-porous abrasive article as claimed in any of the preceding claims, wherein the abrasive aggregates are formed by incorporating the abrasive particles in a metallic bonding material while it is in a softened or liquid condition and in the presence of a non-oxidising atmosphere.

5. A dense non-porous abrasive article as claimed in claim 4, wherein, in forming abrasive aggregates, the mixture of abrasive particles and softened or liquid metal is subjected to a jarring action.

6. A dense non-porous bonded abrasive article as claimed in any of the preceding claims, wherein the abrasive aggregates are bonded together into a dense structure by a resinous bonding material.

7. A dense non-porous abrasive article as claimed in any of the preceding claims 1 to 5, wherein the abrasive aggregates are bonded together by means of a metal to form the abrasive article.

8. A dense non-porous bonded abrasive article as claimed in claim 1, constructed substantially according to the specific examples herein described.

Dated this 6th day of March, 1937.

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